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Fungus diseases of palms are rare, a fortunate matter if we consider the extraordinary value of these trees to the people of tropical countries. A few have appeared in India in recent years, each apparently confined to a particular part of the country and, while due to different causes, agreeing in their general effects.

KOLE ROGA DISEASE OF BETEL PALMS.

A disease of betel-nut palms (*Areca Catechu*) has been known in the Malnad districts of Mysore particularly near Koppa for many years. It is locally termed "kole roga" or black rot. Up to the present it has not been found elsewhere and, as it does not appear to have extended much during the time it has been observed, it is probably favoured by the special climatic conditions of the locality where it occurs.

The first symptom of the disease appears at the time of flowering. A number of the flowers fall without setting fruits, and their stalks blacken and putrify. The rot gradually extends along the inflorescence and affects the stalks on which nuts are forming, causing the latter to drop while immature. Very often the damage does not stop here. The flower stalk arises from the axil of the lowest leaf and, therefore, leads directly to the base of the swollen green part at the top of the stem. This green portion consists of a number of leaf sheaths, which clasp the young growing end of the palm, forming a thick protective covering to the growing point. The lowest of these sheaths becomes affected near the point of origin of the flower stalk, and a patch of rot makes its appearance at this point. The sheaths next underlying the first are then attacked and, since the internal parts are softer than those outside, the rot spreads with increasing rapidity as it approaches the apical bud. When the growing point in the centre of the bud is reached, it also is destroyed, and the whole head withers and falls off. Not alone therefore

is the crop lost, but the whole tree is killed, the damage caused in the affected districts being very heavy.

In the disease spots on the leaf sheaths and also on the withered fruit stalks, a fungus of the genus *Phytophthora* is found. There is little doubt that this is the cause of the disease. The few species of *Phytophthora* are all virulent parasites, and though the well-known *Phytophthora infestans*, the cause of the potato disease, has been grown on dead substances, its development is much less vigorous than on its living host. The betel palm *Phytophthora* is evidently, from its position, anatomical characters and the enormous quantity of spores which it produces, an active parasite.

The fungus consists of a mycelium or vegetative part living within the tissues of the palm and extending out on to the surface, and of sporangia or reproductive bodies formed exclusively on the external filaments of the mycelium. The internal part consists of colourless threads lying between the cells. Here and there these filaments reach the surface and grow out into short branched threads. At the ends of these, and also sometimes on short stalks set laterally, the sporangia are produced. They are pear-shaped bodies with the broad end attached to the stalk, from which they fall easily. In water they germinate rapidly, giving rise each to a dozen or more tiny swimming spores, the zoospores. These swim off in all directions and after a time come to rest, get quite round and in their turn germinate by putting out a thread. It is by means of these sporangia and zoospores that the disease is propagated.

Since for their proper germination *Phytophthora* sporangia require to fall into water, most if not all the diseases due to these fungi are closely dependent on conditions of moisture and rainfall. For the spread of the betel-nut disease, which appears to begin on the flower and fruit stalks, it is necessary that the moisture conditions should be favourable during the time of setting of the fruit. The heavy monsoon rains in these parts of Mysore begin in June and last until the end of August or September. The following observations may serve to explain the increase in severity of the disease in recent years, and also its restriction to a single area.

When the disease first made its appearance, some thirty or forty years ago, it was customary to harvest the nuts in November or December. For the last twenty years the harvest has become earlier, being sometimes collected as soon as July or August. This indicates a change in the habit of the tree, due either to a different method of treatment or the introduction of an earlier variety. The effect of this is to expose the fruit stalks to infection at a time when the moisture conditions are most favourable for its growth. In some gardens the harvest is still gathered in December, and in

these I was informed that there is little complaint of loss from the disease. In Mudigere and adjoining parts of Mysore the harvest is ordinarily in December and January, and the disease does not appear to have obtained a hold in this district. Similarly, though the whole of the country approaching the ghats obtains a very heavy rainfall, the harvest is later than at Koppa in most places, and here also I was informed disease does not appear. The cultivators themselves are aware of the deleterious effects of rainfall during the maturation of the nuts. At Koppa they have devised a remarkable method of protecting the bunches during the monsoon. Before the commencement of the rains each bunch is covered with a thatch made of the leaves or expanded flower stalks of the palm. It is stated that considerable benefit has resulted from this practice.

In endeavouring to check the disease, two objects should be aimed at. The first is to revert, if possible, to the late harvested crop of former years. This may be possible by altering the methods of cultivation now in use in the betel gardens. To ascertain if this is possible, a much fuller inquiry is necessary than I was able to undertake. It may be that by a less forcing treatment—the palms are in many places trenched to a depth of six inches, the trench filled with cattle manure, and a mulch of leaves, new soil, etc., applied round their bases—a later crop would be obtained. Experiments are necessary to settle this point and also the degree to which it will be really effective in preventing the spread of the disease. Search should also be made for later varieties of betel palm, if such exist.

The other and more efficient method of prevention is the improvement of the covers used for the bunches. The covers now in use are far from satisfactory. They dry and crack in fine weather, and during long continued rain rot and fall to pieces. They are tied over the bunches as soon as the rains begin, and no disadvantage appears to result from the shade which they cause. But leaky covers are likely to be worse than none at all, for they check evaporation and ventilation, and preserve a moist atmosphere around the bunches which is bound to favour the growth of the fungus. The use of tin covers would, I believe, not be beyond the means of the well-to-do owners of gardens, and would be far more effective than the palm ones. An educated native of Koppa informed me that he had made experiments with zinc covers with very good results, the covered nuts remaining quite sound while those uncovered rotted. The tin covers would last for several years and, if made on a sufficiently large scale, would not cost a sum beyond the reach of the ordinary betel grower, and would repay their cost in a single year in all probability. It is well worth while endeavouring to introduce the use of these tin covers in the affected districts as a substitute for the leaf ones.

BETEL NUT PLAGUE IN SYLHET.

The cultivation of the betel palm is one of the chief industries of many tracts in Sylhet, and a serious disease would be expected to attract a considerable amount of attention. It is, however, a curious instance of the fatalism which is such a bar in India to the application of certain sorts of scientific agricultural practice, that the disease here mentioned should scarcely have been heard of until a couple of years ago. As a matter of fact, enormous number of palms are dying over a large extent of country, and the cultivators themselves are in a state of passive despair in face of a calamity which they cannot understand.

The extent of the area affected is quite unknown, but it includes almost if not quite the whole of North Sylhet. I have seen the disease from Chhatak to Badarpur in greater or less severity, but there are centres where the loss is very much more serious than elsewhere. One of these is Kanairghat which I visited in May 1905. In Kanairghat and the surrounding villages there are hundreds of acres of betel gardens, and the actual loss suffered amounts in many cases to more than seventy-five rupees an acre annually, while some gardens were seen in which fifteen-sixteenths of the trees had been killed.

The symptoms are quite characteristic and are readily recognised by the villagers. As in the Mysore disease, one of the earliest signs is a dropping of the nuts. Almost the whole produce of the palm may be lost in this way at an early stage in the disease. Very soon the swollen green part at the top of the stem, below the leafy head, is found to be diminishing in size, and quite the most striking symptom is this change from the graceful curved swelling of the coverings of the terminal bud to an almost straight-sided cone at the top of the tree. Withering of the outer leaves accompanies this change, leaf after leaf withering until the whole head dries up and falls off. The final appearance is just the same as in "kole roga."

In the early stages of the disease the leaves and terminal bud show no signs of rotting, and even after the outer leaves begin to wither and the head to shrink, the conditions resemble those which would be caused by drought or some general disturbance, and not by a local disease at the crown of the palm. No trace of any parasite fungus can be found in the earlier stages at the top of the tree. The stem is generally healthy. Below ground, however, matters are different. Here there is invariably a rot, either of the roots or of the below-ground part of the stem, even in very early cases. A large number of trees of all ages were dug out and examined, with the result that the presence of a root disease was placed beyond doubt. In some cases the base of the stem itself remained healthy,

while all or most of the feeding roots were destroyed. In others the rot was more visible in the stem. The characters of the rot were similar in all cases, the wood being turned brown and filled with the mycelium of a fungus. Usually this fungus was found to have invaded the ends of the roots and to have progressed along these into the stem, killing the tissues as it advanced. But whether it originates in the roots or appears first in the tissues of the "collar," the effects are always the same and are quite sufficient to account for the death of the trees.

A number of root-destroying fungi are known in different parts of the world. In most cases their attack is more or less similar to the above. The Himalayan deodar disease, due to *Fomes annosus*, attacks at first the lateral roots and works its way into the stem, where it sets up a destructive rot eventually killing the tree. Similarly the Rosellinias, of which several different species are responsible for the disease known as "stump rot," which is so common in tea and coffee estates, act in much the same manner. In all, from the position of the attack, remedial measures are extremely difficult, though the fungus may be prevented if taken in time from spreading to adjoining trees. The case which has been most fully tested is "stump rot." Several outbreaks of this have been checked on the writer's recommendation by trenches carried round the diseased patch in the earlier stages. The trenches were about two feet deep and a foot broad and were carried well outside the ground which the diseased roots might be expected to occupy. The trees inside the trench were pulled up and burnt, the ground being levelled and allowed to remain fallow for over a year. No new cases occurred outside the trench, though where this treatment is not adopted the diseased patch continues to expand almost indefinitely. Similar results have been obtained in Ceylon and elsewhere.

The following observation suggests that the same treatment may be successful in checking the betel-palm root disease. In a village near Kanairghat, I visited a very large garden in which over fifty per cent. of the palms were dead or dying. One corner of this was found almost entirely free from the disease. This was separated from the rest by a ditch which cut off sharply the diseased from the healthy portion. Everything appeared to indicate that the salvation of this part of the garden was due to the presence of the ditch.

To be effective, trenching must be undertaken as soon as the first disease appears in a garden. The trench should be two feet deep, about a foot broad and drained so as to prevent water accumulating in it. It should entirely surround and cut off the first affected palms. It is unusual for the whole of a garden to be attacked simultaneously. Generally one or a few trees are

first affected, the disease spreading from these. Though it is probable that a part of the spreading is due to spores, infected soil or something of the sort being conveyed through the air or on the feet of the cultivators, the main infection occurs through the ground. Very few known fungi travel through the subsoil, most living in the upper layers and, where parasitic, attacking the superficial roots only. Hence a gap in the soil two feet deep is amply sufficient to stop this progress. But while the mycelium cannot gain accress through the air, it probably can through stagnant water and certainly through dead leaves or debris, should any be allowed to lie in the trench. Hence it is absolutely necessary to keep the latter clean and to drain off any standing water which may lodge in it. Should it be desired to utilise the ground inside the trench for replanting at an early period, the diseased palms should be cut down and their roots dug out and the ground turned over at frequent intervals for a year. This by itself is frequently sufficient to destroy the last traces of a parasitic fungus in the soil, but the process may often be shortened by adding lime. When the palms have been removed, a crop of plantains or other garden produce can be immediately grown with safety, as the disease does not spread to any of the common crops seen. After a year, if treated as above, betel palms may be transplanted to the infected place and will probably escape attack.

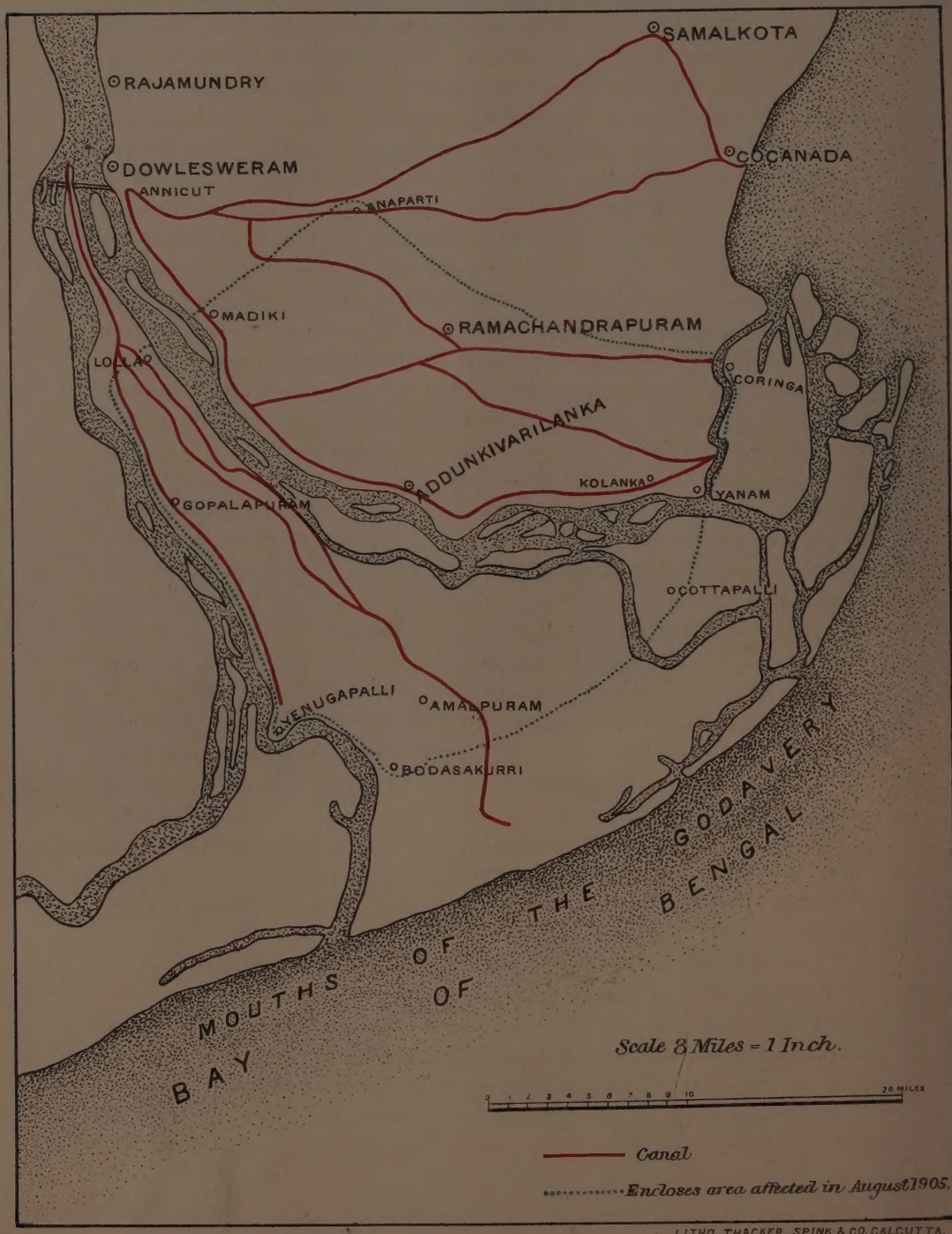
As regards the identity of the fungus, little can be said. From the presence of what are known as "clamp-connections" in the mycelium, it is probably one of the "higher" fungi—toadstools, bracket fungi or their allies. One such was found very frequently on the base of the stem of dead trees and has been identified as *Fomes lucidus*, a common tropical fungus, which there is considerable reason to suspect of parasitism on trees. But it is quite impossible to speak with any degree of certainty, and the actual working out of the cause of the disease would probably occupy a mycologist for many months. Enough has been said above to make it clear that the disease is a root rot and that there is evidence of its spread chiefly through the soil; and this being so, the treatment must follow the lines above suggested, direct cure being out of the question.

Disease of palmyra and other palms in the Godavari.

It was stated in 1904 that a disease was ravaging the palmyra palm (*Borassus flabellifer*) plantations which are such a feature of the landscape in the Godavari Delta. Next year it was reported that cocoanut palms were also being attacked, and the danger which might arise if such a disease spread to the rich palm-growing districts of South India was at once apparent.

PLATE XX.

MAP SHOWING AREA AFFECTED BY PALM DISEASE IN THE GODAVERY DELTA.



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The disease is said to have been noticed as far back as 1897. It has, however, only attracted attention by its extension within the past two or three years. It is said to have been seen first in Addunkivarilanka, an island in the north channel of the Godavari (*see* plate XX). From here it spread to the Amalpuram taluk on the southern bank and to the Ramachandrapuram taluk on the northern bank. It is now found in an area on both sides of the northern channel, occupying the whole of the Amalpuram taluk except the swampy district towards the sea, while on the Ramachandrapuram side it has reached Anaparti, about twelve miles from the river. Along the banks it extends some thirty miles, from the vicinity of the French settlement of Yanam to Madiki and Lolla. As in most other cases of infectious disease, it does not occupy an absolutely continuous area. Some villages have escaped though surrounded by diseased localities, and in some directions extension has progressed much more than in others. Thus the disease has been known at Polanka for six or eight years, and a mile or two to the east the palms are dead in great numbers ; yet another mile along the canal not a single case was seen in thousands of palms visible from the banks. It may, however, be said in a general way, that in a circle from the centre at Addunkivarilanka where it is said to have started, with a radius of fourteen miles, most of the villages are affected. In the portion of the Coconada taluk towards the river, some twenty-five villages have reported the presence of the disease.

In the early period of the epidemic, the opinion was held by many of the local officials and prominent landholders that insects, particularly a large (cockchafer) grub which is common enough in diseased trees, were the cause of death. But it is certain that they have nothing to do with it, for the whole nature of the disease is opposed to such a view, and a number of trees in the early stages were examined without finding the grub. The sharp limitation of the affected locality such as is found, for instance, near Yanam and Kolanka, joined to the slow spread through an almost continuous area, shows an infection by some germ incapable of rapid transmission. Most of the persons with whom I discussed the disease had already given up the idea that it is due to insects.

The extent of the damage can only very roughly be estimated. Along the Amalpur east bank canal seventy-six per cent. of one hundred and thirty consecutively counted palms were dead. This was a very bad place. In a similar line near Kolanka thirty per cent. were dead. Elsewhere every proportion down to few or no dead trees was seen. Possibly about ten per cent. of the palmyra palms of the above mentioned area have been killed. The trees are said to be worth from one to two rupees per annum, and the loss

already sustained, though much less than that due to the Sylhet betel palm plague, must run into lakhs.

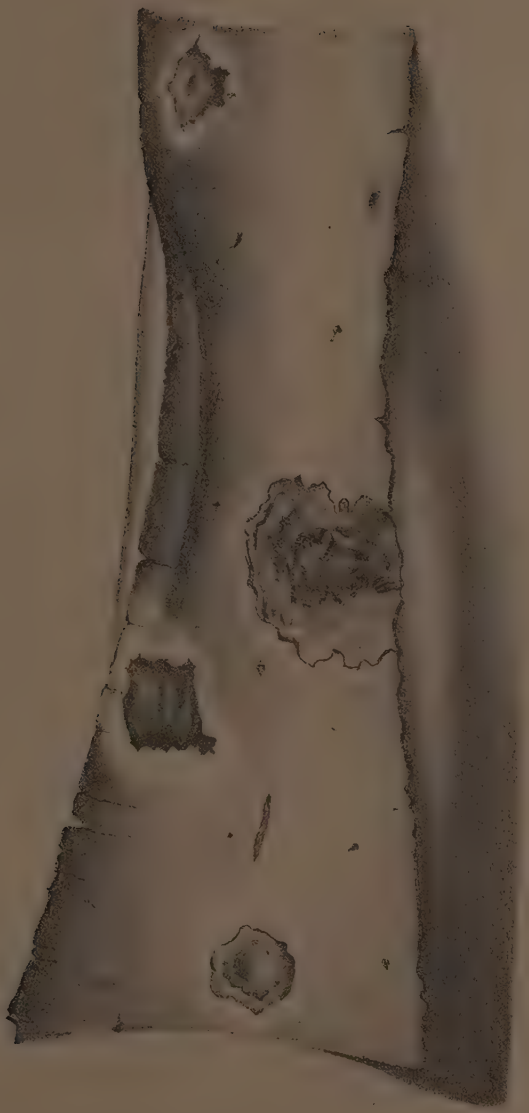
The most serious aspect of the matter is the fact that cocoanut palms are undoubtedly subject to infection. In Ramachandrapuram taluk a few cases only were seen, but in Amalpuram they are numerous, though fewer than in the palmyra. This is perhaps due to their harder tissues which oppose a barrier to infection. In one locality some two hundred dead cocoanut trees were seen ; elsewhere only a dozen or two. The danger is that the disease may increase in virulence in regard to cocoanut palms if allowed to rage unchecked, and this is the most urgent reason why prompt measures to stamp it out are called for. A few betel palms were found attacked apparently by the same disease, but the cases were too far gone for satisfactory examination.

As in the other palm diseases above described, the symptoms are such that it can be recognised fairly easily. Most of the proprietors were able to point out even the early cases, their statements being checked by cutting down a number of the palms indicated. The earliest sign is an alteration in colour of one of the leaves, usually one of those recently expanded towards the centre of the bud. This turns white and soon afterwards commences to wither. Other leaves are attacked in turn, the heart of the bud is reached and the whole top withers and falls off, the last stage often being reached only after a considerable time. In cocoanut palms the same general course is followed, but here if the nuts have been formed before the attack becomes severe, they are often dropped prematurely. No new nuts are formed once the characteristic symptoms show. No case of absolute recovery was met with, but in one or two seen it was said that the disease had been checked for a time and had then recommenced.

The whole of the stem and root system is perfectly healthy up to a late stage in the disease. With the crown, however, the case is otherwise. The expanded parts of the leaves are, it is true, unaltered and apparently healthy until withering sets in. In the leaf sheaths, however, the signs of disease are unmistakeable. These sheaths are a remarkable feature of the structure of most palms. They form a series of twenty or thirty tube-like layers closely applied one under another so as to form a funnel. The actual top of the stem or apical bud is sunk in the centre of this funnel and protected by it, a protection which is a necessary one, for it is the most vulnerable part of the tree and death follows its destruction. To reach the apical bud a parasite must penetrate these layers. This is what actually happens.

The leaf sheaths of all diseased trees are marked by irregular, sunken spots in greater or less number (Plate XXI). In the earlier stages, and

PLATE XXI.



LEAF SHEATH OF PALMYRA PALM
SHOWING DISEASE SPOTS.

particularly in the inner layers where young ones are often numerous, the spots are white ; later on they become brown. They are always sunken and usually have somewhat raised edges. They begin on the outer sheaths and may be traced in through succeeding ones towards the heart of the bud. As the inner layers are softer, the inside patches are often larger than those outside, and may even give rise to new patches which extend out again to the outside sheath. In all cases, however, the first appearance is on the outer sheaths. The earlier patches are dry and either free from any appearance of a parasite on the surface or covered with a white mycelial felt. Very soon a wet rot follows, which extends with great rapidity in the delicate central tissues and converts the whole heart into a foul smelling mass of putrefaction, in which everything is involved, and the original agent is lost sight of. It is at this stage that the insect grubs referred to make their appearance, possibly attracted by the smell. They are, however, of several different kinds, often absent altogether, and evidently not connected with the disease.

It is only in the early stages before the wet rot starts that the true cause can be made out. This is a fungus of the genus *Pythium*, a near ally of the *Phytophthora* found in " kole roga." In quite young spots the mycelium is found only within the leaf sheath tissues, where its threads extend between the cells, sending little branches or haustoria into them. These are the feeding organs of the fungus by means of which it absorbs the living cell substance and kills the cells. Later on it comes out on the surface, forming often a dense white felt or filaments bearing sporangia. The fungus resembles that found in " kole roga." It is, however, formed of larger threads and has a different manner of germination of the sporangia. Instead of the zoospores escaping directly from the sporangium after it falls into water, they come out in an immature condition into a thin bladder formed at its top and finish their development here. Then they escape and swim off in every direction. After they come to rest, they germinate quickly by putting out a thread which can reproduce the whole fungus.

Dissemination may be brought about in several ways. Withering of the head may expose the inner sheaths where most of the spores are produced, or some of the latter may occasionally form on the outer layer especially on the secondary spots which develop from diseased patches in the inside ; in either case they would be carried about by the wind. Once the wet rot which invariably follows has appeared, this mode of spread is not likely to occur, though there is a second spore form sometimes produced, which may be capable of surviving the general putrefaction. This second spore is a sexually produced " oospore" with thick walls and germinating in a different manner to the ordinary sporangia. It belongs to a class of spore forms

whose chief function seems to be to carry on the life of the fungus plant through periods of hardship ; for while the ordinary sporangia can only germinate within a few days from their time of formation, the oospores can often remain capable of germination for many months. It is quite possible that when the whole head has rotted away, these spores get blown about and germinate on a new palm. Insects also may assist in the spread, should they gain access to the sporebearing mycelium on the surface of the spots. Infection might also be carried by the knives of the toddy drawers, since each tree is climbed every year either to draw toddy or to cut the leaves. But whatever the usual mode of conveyance, it is evidently slow, and this is probably due to the fact that spore formation occurs usually between the inner layers of the bud, where they are not exposed to wind or any other of the usual modes of dissemination.

Nothing but the most energetic action is likely to avail in checking a disease of this kind. No remedial measures intended to cure trees already attacked are possible. The disease is invariably fatal, and only drastic measures directed to removing the source of infection can be relied on as being of the least use. In view of the fact that the area affected is small and that, so far, the disease is not known to exist outside the Godavari Delta, a vigorous effort is required to stamp it out before it has got beyond control.

The disease may be fought in two ways. The formation of spores may be checked by cutting off the bud from the stem as soon as the first leaf turns white. This entails little real loss except the cost of labour, for the palm is doomed once the early symptoms appear, and the flow of toddy on which the chief value of the tree depends is likely to be small during the remainder of its life. At the same time infection of healthy trees can be guarded against by brushing or spraying the outside of the bud below the expanded leaves with a fungicide.

The following suggestions are made for an organised campaign against the disease. A special staff is required, for it is certain that, at first at least, the villagers will be slow to take measures for their own protection. If, however, the results bear out the value of the work, real co-operation may be expected before long. A number of expert palm climbers (such as toddy drawers) should be selected under the charge of an agricultural inspector or some similar official and provided with small axes or saws. They should be instructed to climb all diseased trees, both those in the early stages and those already dead, and to cut off the green tops below the swelling of the leaf sheaths. It is particularly essential that all trees in the early stages should be dealt with, and these can be recognized, where the villagers themselves are unable to do so, by the whitening of one of the leaves towards the centre

of the head. After cutting off the heads, the whole of the tops should be collected into a heap in each village and burned. In this way every dead or attacked palm in a selected area would have its power of spreading infection destroyed by burning the diseased parts, and this measure alone, if steadily pursued, is certain to give good results. The infectious matter is confined to the head of the palm and, as the tree is doomed once the disease appears and will yield little or no further profit, its removal costs little but the actual expense of labour in cutting it down and burning it.

To save healthy trees within the affected districts, in places where they are surrounded by large numbers of dead or dying trees, is difficult unless the above measures are very thoroughly carried out. But the chances of their infection may be very largely diminished if they are brushed with Bordeaux mixture on the leaf sheaths when the removal of diseased trees commences. Bordeaux mixture is a substance which adheres strongly to the surfaces of plants and, being poisonous to fungus spores, it prevents their germination or kills the young germ filaments as soon as they appear. A second gang of toddy drawers should be employed for this work and provided with small vessels containing the mixture and mops of rags for brushing it on to the sheaths. The expanded leaves need not be brushed, but only the leaf sheaths below these. One man should be able to do from 30 to 50 trees in a day, and if the work is done at the time that the trees are climbed for cutting the leaves, the cost of the labour should be small. The men employed for removing diseased trees should not be allowed to climb healthy ones, as there is some danger of their conveying the infection on their persons or axes. The cost of the materials used cannot be exactly given as it depends on the price at which copper sulphate can be landed in the district and the availability of a supply of good lime in the neighbourhood. A pint would probably be nearly enough to treat one tree, and this should not cost more than about one pie.

To prepare 50 gallons of the mixture, weigh out 6 lbs. copper sulphate, break to powder and dissolve in 25 gallons of cold water by suspending in a piece of gunny sacking in the water. The latter must not be contained in a metal vessel but in a barrel or big earthenware pot. In another vessel weigh out 4 lbs. of fresh quicklime. Slake this gradually till it falls to powder and then add water up to 25 gallons. Allow it to cool. When cool, add to the copper sulphate solution through a sieve so as to retain any lumps. A thick bluish liquid results which on standing throws down a bluish precipitate, leaving the other part of the liquid clear. To test if fit for use, add a few drops of Ferrocyanide of Potassium to a small quantity of the clear liquid in a dish. If a brownish precipitate appears, more lime must be added till no precipitate

is given on testing. Or a clean steel knife may be dipped in it and if more lime is necessary, a deposit of copper will form on the knife. If none is formed, it is ready for use. Stir well before using.

Similar remedies have been advocated for a cocoanut palm disease known as "bud rot," which is attracting much attention in Cuba and the West Indies at the present time. This disease has many points of similarity to the Godavari one, though different causes have been provisionally assigned for it. It has been found by Mr. Cradwick in Jamaica that spraying the trees with Bordeaux mixture when they show the first sign of disease has been effectual, and it is hoped, in Jamaica at all events, that with the use of Bordeaux mixture the disease may be kept in hand. Mr. Busck of the Division of Entomology of the U. S. Department of Agriculture, who investigated the disease in Cuba in 1901, believes it to be a fungal one and considers that its fatal nature precludes a remedy for trees already infected and leaves only the prevention of the spread of the disease as the object for man's intervention. He recommends the cutting down and burning of the tops of the diseased palms. Dr. Erwin Smith of the same Department studied the disease in Cuba in 1904. He believes the disease to be a bacterial one but gives the same general measures for treatment. Diseased trees should be felled and the terminal bud burned or properly disinfected with sulphate of copper. Mr. Petch, Government Mycologist, Ceylon, gives an account of a cocoanut disease, which he considers identical with "bud rot," in a recent circular of the Royal Botanical Gardens, Ceylon. He also recommends the removal and burning of the tops of diseased trees.

To be effective it is absolutely necessary to have united action in carrying out the measures recommended above. It is useless for one village to remove the source of infection if diseased trees are allowed to remain in neighbouring fields to convey infection back again. But the opportunity is a rare one, for the limitation of the disease is such as to render concerted action possible, and there is at least a fair prospect of being able to stamp it out before it passes beyond control.